International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 2, Mar-Apr-2026, ISSN (Online): 2395-566X

A Review on Integrated Facial Attendance and Sentiment Tracking Systems Using Expression Recognition

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Abstract- Traditional attendance monitoring systems rely heavily on manual processes or contact-based biometric solutions, which often lead to inefficiencies, proxy attendance, and lack of real-time behavioural insights [7]. Recent advancements in computer vision [5] have introduced facial recognition-based attendance systems; however, most existing solutions focus only on identity verification and fail to analyze participant engagement or emotional response during sessions [6]. This paper presents a comprehensive review and analysis of an integrated Facial Attendance and Sentiment Tracking System (FASTER), which combines real-time face detection [1], facial recognition using LBPH [2] and SVM classifiers [3], and expression-based sentiment monitoring [6] within a lightweight client-server architecture. Unlike previous systems that utilize either attendance automation or emotion detection independently, the proposed approach integrates both functionalities using OpenCV-based face detection [8], machine learning classifiers, and real-time data logging mechanisms. The system emphasizes low computational overhead, offline ca- pability, and user-friendly GUI-based interaction, making it suit- able for educational and organizational environments. Through comparative analysis with existing research, this study identifies key limitations in prior work and highlights the novelty of a unified attendance and sentiment-aware monitoring framework.

Keywords – Face Recognition, Attendance System, Facial Expression Recognition, Computer Vision.

I. INTRODUCTION

In modern educational institutions and organizational environments, attendance monitoring plays a critical role in maintaining productivity, security, and administrative transparency. Traditional attendance systems such as manual roll calls, paper-based registers, and RFID or biometric devices are often time-consuming, prone to proxy attendance, and lack real- time analytical capabilities [7]. With the rapid advancement of computer vision and machine learning technologies [5], facial recognition-based attendance systems have emerged as a contactless and automated alternative. These systems aim to improve accuracy, reduce human intervention, and streamline administrative workflows.

Recent studies have explored several techniques for automated attendance, including Haar Cascade-based face detection [1], Local Binary Pattern Histogram (LBPH) recognition [2], and Support Vector Machine (SVM) classifiers [3] for identity verification. While these approaches have significantly enhanced recognition accuracy and reduced computational complexity, most existing solutions focus solely on attendance automation without considering behavioural or emotional engagement analysis. Parallel advancements in facial expression recognition [6] have enabled sentiment analysis in educational settings; however, such systems often operate independently and lack integration with attendance management frameworks. The absence of a unified platform that combines facial recognition with sentiment-aware monitoring highlights a significant research gap. Existing market solutions such as standalone facial recognition APIs or emotion analysis platforms [8] provide partial functionalities, leading to fragmented workflows and increased deployment complexity. Furthermore, many deep learning-based approaches such as CNN and FaceNet [4] require high computational resources and cloud dependency, making them less suitable for lightweight real-time deployments.

To address these limitations, this study reviews and analyzes the design principles of an integrated Facial Attendance and Sentiment Tracking via Expression Recognition (FASTER) framework. The proposed approach combines real-time face detection, feature extraction, classification, and emotional state analysis within a client-server architecture [5]. By leveraging lightweight machine learning techniques and GUI-based interaction, the system aims to deliver efficient performance with

minimal hardware requirements while maintaining scalability and usability.

The main contributions of this review are summarized as follows:

- Analysis of traditional and AI-driven attendance monitoring techniques.
- Comparative evaluation of facial recognition and sentiment analysis systems.
- Identification of research gaps in existing single-purpose solutions.
- Presentation of an integrated lightweight framework that combines attendance automation with expression-based engagement tracking.

The remainder of this paper is organized as follows. Section II discusses the background concepts and technical founda- tions of facial detection, recognition, and expression analysis. Section III presents the literature review and comparative analysis of existing systems. Section IV highlights research gaps and challenges, followed by conclusions and future research directions.

II. BACKGROUND AND TECHNICAL FOUNDATIONS

Automated attendance systems based on computer vision [5] rely on multiple core technologies, including face detection, feature extraction, classification, and facial expression analysis. This section presents the technical background required to understand the development of integrated facial attendance and sentiment monitoring frameworks.

A. Face Detection Techniques

Face detection is the initial stage of any facial recogni- tion pipeline. It involves identifying and localizing human faces from images or real-time video streams. Traditional approaches such as the Haar Cascade classifier [1] have been widely adopted due to their lightweight computation and real-time performance. The algorithm uses Haar-like features and an integral image representation to detect facial regions efficiently [1]. The detection process can be represented as:

$$F(x) = \sum_{i=1}^{n} w_i h_i(x)$$

where hi(x) represents Haar features and wi denotes learned weights obtained during training.

Despite the emergence of deep learning-based detectors such as CNN-based models [4], Haar Cascade methods remain suitable for resource-constrained environments because of their low processing overhead and fast execution speed.

B. Facial Feature Extraction and Recognition

After detecting faces, feature extraction converts facial textures into a numerical representation for recognition. Local Binary Pattern Histogram (LBPH) [2] is a commonly used technique due to its robustness against illumination changes and facial variations. The LBPH operator labels pixels by thresholding the neighbourhood around each pixel and forming a binary pattern. The LBP value can be expressed as:

$$LBP(x_c, y_c) = \sum_{p=0}^{P-1} s(i_p - i_c) \cdot 2^p$$

where ic is the center pixel intensity, ip represents surround- ing pixels, and s(.) is a thresholding function.

Support Vector Machines (SVM) [3] are often used for classification after feature extraction. SVM aims to find an optimal hyperplane that separates facial feature vectors into different identity classes. The decision boundary is defined as:

$$w \cdot x + b = 0 \qquad (3)$$

where w represents the weight vector and b is the bias term.

Facial Expression and Sentiment Analysis

Facial expression recognition [6] extends beyond identity verification by analyzing emotional states such as happiness, neutrality, or sadness. Expression analysis typically relies on facial landmarks, texture descriptors, or machine learning models trained on labeled emotion datasets [6]. Integrating sentiment analysis with attendance monitoring provides additional insights into user engagement and behavioural patterns. Unlike conventional attendance systems that focus only on identity recognition, expression-aware systems aim to capture qualitative information related to participant interaction. This integration forms the foundation for intelligent classroom analytics and adaptive learning environments.

Client-Server Architecture in Real-Time Vision Systems

Many modern attendance frameworks adopt a client-server architecture [5] to separate data acquisition from computational processing. The client captures images through camera modules, while the server performs preprocessing, feature extraction, and classification. Such architecture improves scalability, enables modular design, and allows real-time feedback to users through graphical interfaces.

III. LITERATURE REVIEW AND COMPARATIVE ANALYSIS

Over the past decade, significant research has been con- ducted in the field of automated attendance monitoring using computer vision and machine learning techniques [5]. The literature can broadly be categorized into three major do- mains: face detection-based systems, face recognition-based attendance frameworks, and facial expression or sentiment analysis models [6]. This section provides an extended analysis of

previous studies and highlights their limitations in relation to integrated attendance and engagement monitoring.

A. Face Detection-Based Attendance Systems

Early research focused primarily on real-time face detection techniques to automate identity verification in classrooms and workplaces. Traditional methods such as the Viola-Jones Haar Cascade algorithm [1] demonstrated efficient performance in detecting faces with minimal computational resources. Several studies emphasized the importance of lightweight detection models that could operate on standard hardware without requiring GPU acceleration.

Researchers observed that while Haar Cascade-based sys- tems [1] achieved real-time performance, they often strug- gled with variations in illumination, facial occlusions, and complex backgrounds. Later improvements introduced hy- brid approaches combining Histogram of Oriented Gradients (HOG) features [5] and machine learning classifiers to enhance detection accuracy. Despite these advancements, most early detection-focused systems lacked a comprehensive attendance management pipeline and primarily served as proof-of-concept implementations.

B. Face Recognition-Based Attendance Frameworks

With the evolution of machine learning, attendance sys- tems began integrating facial recognition techniques such as Eigenfaces, Fisherfaces, and Local Binary Patterns Histograms (LBPH) [2]. Studies have shown that LBPH provides strong performance under varying lighting conditions and requires relatively small training datasets. Researchers further incorpo- rated Support Vector Machines (SVM) [3] to classify facial embeddings, achieving improved recognition accuracy in real- time environments.

Deep learning-based models such as FaceNet [4] and con- volutional neural networks (CNNs) later gained popularity due to their high accuracy; however, they often required extensive datasets and computational resources. Several aca- demic projects proposed hybrid systems combining OpenCV- based face detection [8] with machine learning classifiers to automate attendance logging through CSV or database storage. While these systems significantly reduced manual workload and minimized proxy attendance, they typically focused only on identity verification without incorporating behavioural anal- ysis.

Another limitation observed in prior work was the depen- dence on cloud-based services for facial recognition, which introduced privacy concerns and network latency issues. Lightweight offline systems addressed these challenges by utilizing traditional feature extraction methods, making them suitable for educational institutions with limited infrastructure.

C. Facial Expression and Sentiment Analysis Systems

Parallel research in affective computing introduced facial expression recognition models [6] aimed at understanding emotional states and user engagement. These systems utilized feature extraction techniques such as LBP, HOG, and deep neural networks [4], [5] to classify expressions like happiness, sadness, and neutrality. Studies in smart classroom environ- ments demonstrated that expression analysis could provide valuable insights into student attentiveness and participation.
Despite their effectiveness, most sentiment analysis systems operated independently from attendance monitoring frame- works. Existing emotion recognition platforms often required cloud APIs [8] or heavy deep learning models [4], which lim- ited their real-time applicability in low-resource settings. Fur- thermore, researchers identified challenges related to dataset bias, variations in facial expressions across individuals, and real-time processing constraints.

D. Integrated Systems and Research Challenges

Only a limited number of studies attempted to combine facial recognition with expression analysis into a single frame- work. These integrated approaches faced several challenges, including increased computational complexity, system latency, and difficulties in synchronizing recognition with emotion de- tection pipelines. Additionally, many existing solutions lacked modular client-server architecture [5], making scalability and real-time deployment difficult.

The absence of lightweight, unified systems capable of per- forming attendance automation alongside sentiment tracking highlights a significant research gap. Most previous works addressed either identity verification or emotional analysis individually, resulting in fragmented solutions that required multiple tools or external APIs.

E. Comparative Analysis of Existing Approaches

Table I presents a comparative overview of representative approaches discussed in the literature. The analysis highlights the strengths and limitations of existing systems and empha- sizes the need for an integrated and efficient framework.

TABLE I
COMPARATIVE ANALYSIS OF ATTENDANCE AND EXPRESSION SYSTEMS

Approach	Technique	Advantage	Limitation
Detection-Based	Haar Cascade [1]	Fast real-time detection	No sentiment analysis
Recognition-Based	LBPH + SVM [2], [3]	Lightweight recognition	Limited behaviour insight
Deep Learning	CNN/ FaceNet [4]	High accuracy	High computation need

Emotion Platforms	Expression Mod- els [6]	Engagement tracking	No attendance feature

The literature review clearly demonstrates that although numerous advancements have been made in face detection, recognition, and emotion analysis, the integration of these components into a single lightweight system remains an open research challenge. This motivates the need for unified frameworks that can simultaneously automate attendance and analyze user engagement while maintaining computational efficiency.

IV. COMPARATIVE ANALYSIS

A detailed comparative evaluation of existing attendance and expression recognition systems reveals substantial differ- ences in terms of architecture, computational requirements, and functional capabilities [5]. Traditional attendance systems primarily focus on detecting and recognizing faces to auto- mate identity verification [7]. While these systems improve efficiency compared to manual methods, they lack the ability to analyze user engagement or emotional response during sessions.

Detection-based approaches utilizing Haar Cascade algo- rithms [1] offer real-time performance and low computational complexity, making them suitable for resource- constrained environments. However, these methods are limited to face localization and do not provide deeper analytical insights. Recognition-based systems employing LBPH [2] and SVM classifiers [3] extend functionality by enabling reliable identity classification with moderate accuracy. Despite their efficiency, these systems remain restricted to attendance tracking and fail to incorporate behavioural analysis.

Deep learning-based solutions, including convolutional neu- ral networks (CNN) and FaceNet architectures [4], demon- strate high accuracy in facial recognition tasks. Nevertheless, they introduce challenges related to hardware dependency, model training complexity, and privacy concerns associated with cloud processing. Similarly, standalone facial expression analysis platforms [6] provide engagement monitoring but lack automated attendance logging, resulting in fragmented system workflows.

In contrast, the integrated framework reviewed in this study combines facial recognition and sentiment tracking within a unified architecture [5]. This integration reduces system fragmentation and enhances the analytical value of attendance data. Table II presents a comparative summary of representa- tive approaches.

TABLE II
EXTENDED COMPARATIVE ANALYSIS OF EXISTING APPROACHES

System Type	Technique	RT	Sentiment	Comp.
Detection-Based	Haar Cascade [1]	Yes	No	Low
Recognition-Based	LBPH + SVM [2], [3]	Yes	No	Med
Deep Learning	CNN / FaceNet [4]	Part	Lim	High
Emotion Platforms	Expression Models [6]	Yes	Yes	High
Integrated Framework	Detection + Recogni- tion + Emotion	Yes	Yes	Mod

The comparative analysis demonstrates that existing systems provide only partial solutions, either focusing on identity recognition or emotional analytics. The integrated approach addresses these limitations by combining both functionali- ties while maintaining computational efficiency. This unified design not only enhances attendance automation but also introduces a new dimension of engagement-aware monitoring suitable for intelligent educational environments.

V. CONCLUSION AND FUTURE SCOPE

This paper presented a comprehensive review and analytical study of facial attendance monitoring and sentiment-aware expression recognition systems. Through an extensive evalua- tion of existing research, it was observed that most traditional approaches focus either on attendance automation or facial expression analysis independently. While face detection and recognition techniques such as Haar Cascade [1], LBPH [2], and SVM [3] have demonstrated efficient performance in real- time environments, the absence of integrated behavioural analytics remains a major limitation in current solutions.

The study identified key research gaps related to frag- mented system design, high computational requirements in deep learning-based frameworks such as CNN and FaceNet [4], and the lack of lightweight architectures capable of operating in resource-constrained environments. In response to these challenges, the reviewed FASTER framework introduces a unified approach that combines identity recognition with expression-based engagement tracking within a scalable client-server model [5]. The integration of attendance logging and sentiment monitoring provides a multidimensional perspective for intelligent classroom and organizational analytics.

From a practical standpoint, the proposed direction em- phasizes computational efficiency, offline capability, and user-friendly graphical interfaces, making it suitable for educa- tional institutions and workplaces where real-time monitoring and privacy-aware deployment are essential. By leveraging traditional machine learning techniques instead of resource-

intensive deep learning models, the framework achieves a balance between performance and accessibility.

Future research may explore the incorporation of deep neu- ral networks [4] for improved emotion classification accuracy, liveness detection mechanisms to prevent spoofing attacks, and cloud-based analytics for large-scale deployments. Additional enhancements may include adaptive learning systems that correlate attendance patterns with engagement metrics, cross-platform mobile interfaces, and privacy-preserving techniques such as federated learning. These advancements can further extend the capabilities of integrated facial attendance and sentiment tracking systems, paving the way toward intelligent and context-aware monitoring solutions.

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